

# ANALYSIS AIMING TO INCREASE THE REGULATORY HYDROGEN LIMIT (2 VOL%) OF CNG(1) VEHICLE TANKS

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- Motivation
- First technical assessment
- Aims of the project and main tasks
- Further steps

# MOTIVATION FOR FURTHER INVESTIGATIONS ON THE H<sub>2</sub>-TOLERANCE OF CNG<sub>1</sub>-TANKS



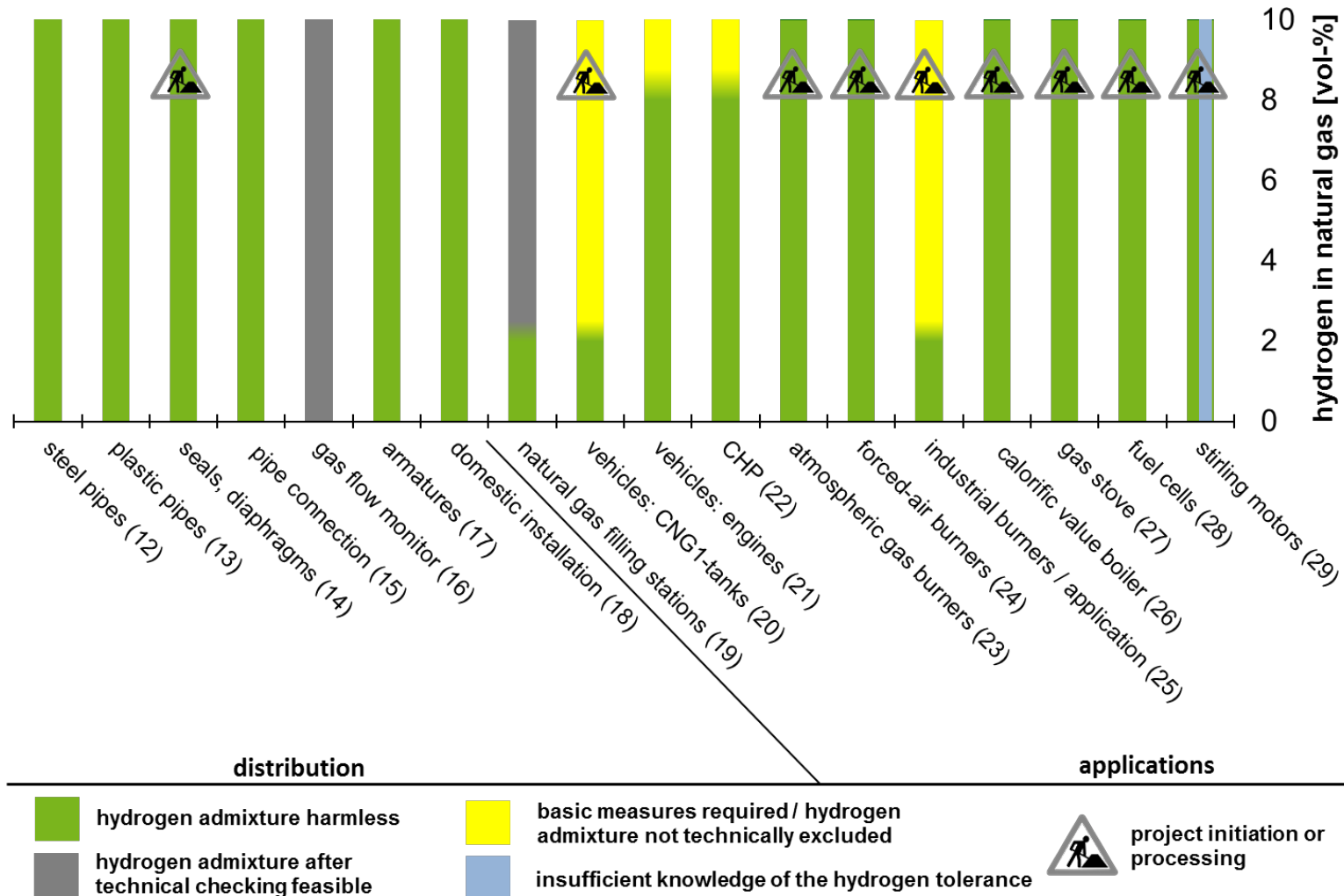


- steel tanks in natural gas vehicles: specification UN ECE R 110 stipulates a limit value for hydrogen of 2 vol%;

Source: HIPS Paper by Dr. Klaus Altfeld/Dave Pinchbeck, 2013

- Various research of the DVGW (e.g. G1-02-12 report on current state) identified open research questions for CNG1 vehicle tanks of gas-driven vehicles (limitation imposed by technical standards).
- CNG1 vehicle tanks and industrial burners are currently the only applications constraining the feed-in of hydrogen in the gas distribution network.
- Upon success to raise this limitation, e.g. to 10 vol%, for newly licenced, gas-driven vehicles:
  - The feed-in of hydrogen in gas distribution networks is exposed to less constrains.
  - The gas distribution infrastructure will be opened soon to the feed-in of renewable hydrogen.
  - The absorption capacity for electricity from renewable sources will be increased (energy storage) and extended for hydrogen based applications.

# Status quo of the discussion on hydrogen limitation (gas distribution grid)



# FIRST TECHNICAL ASSESSMENT



# First technical assessment CNG1 vehicle tanks

## State of the art



- DIN 51624 / ECE R110 limit the allowable hydrogen concentration in natural gas to 2 vol% but:
- Steel of gas-driven vehicle tanks is recommended to be used with pure hydrogen (content 100 vol%) if
  - the material strength does not exceed 950 Mpa and
  - the inner surface will be inspected prior to initial operation.
- Reduction of the permitted content of hydrogen from 100 to 2 vol% if the material strength is exceeded seems unreasonable.
- → Analogies derived from analysis of pipeline steel suggest possible application for hydrogen concentrations exceeding 2 vol%.

# First technical assessment CNG1 vehicle tanks

## Existing experiences (analogy to pipeline steels)



- Basis of knowledge: „NATURALHY“ (Preparation of a hydrogen economy with the use of the natural gas infrastructure as catalyst - SES6/CT/2004/502661)
  - Project duration 2004 – 2009
  - EU 6RP (39 partners - Gasunie, GDF, NUON, DBI , GERG,...)
  - 8 working packages (LCA, Safety, Durability, **Integrity**, End Use,...)
  - Budget: 17 million Euro



# First technical assessment CNG1 vehicle tanks

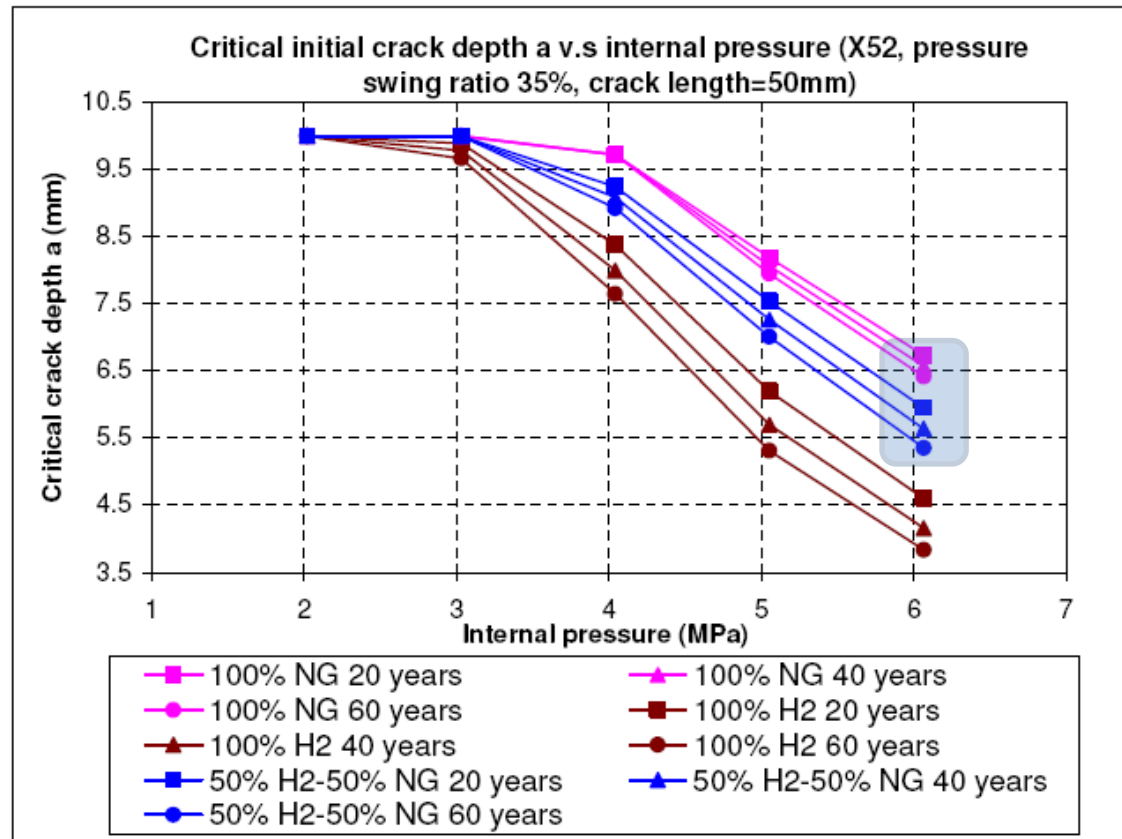
## Existing experiences (analogy to pipe steels)



- Test/modelling conditions of investigation of pipeline steels concerning the effect of hydrogen on crack growth (X 52 after 1975)
  - Max. Operation pressure: 20, 40 und 60 bar
  - Pressure swing: **35% MOP**
  - One cycle per day for 20, 40 and 60 years
  - 100% natural gas, 100% Hydrogen and a 50/50 mixture of both gases
  - Diameter 600 mm, wall thickness 10 mm
  - Surface crack length 50 mm
  - Axial orientation (parent material noch welds oder HAZ)

# First technical assessment CNG1 vehicle tanks

## Existing experiences (analogy to pipe steels - results)



Moderate influence on the initially acceptable crack size at a concentration of **50 vol%** hydrogen.

Operating duration of 60a = 21.900 cycles in the conducted research.

ECE R110 = 20.000 cylv.

Not yet addressed:  
Behaviour on 34 CrMo 4 at a concentration of 10 vol% hydrogen.

# First technical assessment CNG1 vehicle tanks

## Further indications / Situation in other member states



- Effect of hydrogen on steel is connected to special preconditions (dynamic plastic deformation, clean metal surfaces, electrolytes)
- Sweden: Field test „CUTE“, CNG Busses with up to 5 Vol.-% H<sub>2</sub> in NG
- France allowable hydrogen content in NG > 2 Vol.-%
  
- → The 2 Vol.-% limit stipulated by DIN 51624 / ECE R110 seems to be very conservative and should be investigated

# AIMS OF THE PROJECT AND MAIN TASKS





- Strategic selection of project partners
- Compilation of an aim-orientated working schedule to create the technical preconditions that allow a change the hydrogen limitation in CNG vehicle tanks, especially for new gas-driven vehicles.
- Performing the needed research/investigations in order to create the needed knowledge base
- Overcoming legal obstacles by distribution of the results as basis for adjustment of the current technical standards (ECE, DIN) for CNG1 vehicle tanks in the future (applies to new gas-driven vehicles).
- Investigation of the situation for other CNG vehicle tank generations



- **Compilation of a qualified project team comprising:**
  - Manufacturers of CNG vehicle tanks
  - Experts of material science (e.g. BAM / Salzgitter Mannesmann / Evonik)
  - „Problem Owners“ (vehicle manufacturers with a big gas-driven vehicle pool as VW, Fiat)
  - Experts of the gas industry (e.g. E.ONNT with experience from finalised projects)
  - DVGW research institutes with experience in the field of hydrogen tolerance of steel
  
- **Summarising the existing knowledge (e.g. background of the current limitation, experience on hydrogen tolerance of steel, counteractions, ....) and developing a detailed project scope**
  
- **Building a consortia that is willing and able to support the project technically and financially (preferably industrial partners and associations) furthermore the funding opportunity will be investigated**

## Major technical tasks already identified



- Research, understanding and explaining the technical basis for the current limitation of 2 vol%,
- Collecting the available knowledge on possible influences of hydrogen on steels
- Identification of possible counteractions
- Concluding gaps of knowledge and setting up an appropriate testing program
- Performing the tests
- Evaluation of the bodies, groups and associations that needs to be informed on the results in order to open up the opportunity for a wider hydrogen injection limit

# FURTHER STEPS







### Continuing the state of the art analysis

### Finding partners and budget

- |                         |                                     |
|-------------------------|-------------------------------------|
| — BAM                   | contact established                 |
| — Mannesmann Salzgitter | contact initiated                   |
| — Voestalpine           | contact initiated                   |
| — Magna                 | contact initiated (contact by RAG)  |
| — Volkswagen            | contact established                 |
| — Daimler               | contact required (possibly by DVGW) |
| — Fiat                  | contact required (possibly by DVGW) |

### Is this topic an issue for you? – You are welcome!

Energie mit Zukunft.  
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Thank you for your attention!

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